lati, horizontales, interstitia bilinearia. Fructus ignoti, color coccineus; exsiccatus rigidus, chartæ minimè adhærens.

Hab. ad Port Natal.

272. *Martensia,* gen. nov. Frons plana, areolata, avenia, margine fenestrata; fructus duplex; sphærospermia longitudinaliter in reticulo simplici serie disposita; capsulæ sphæricæ, reticulo affixæ, sporidia subglobosa foventes.

M. elegans, Hg. Fronde tenuissima, lobata, segmentis cuneato-rotundatis.

Frons basi affixa, semi usque pollicaris, tenerrima, tenax, cellulis angulatis areolata, margine demum fructificante, clathrato-fenestrata. Color amœnè roseus fugax. Chartæ arctè adhærens.

Port Natal ad lapides.

In memoriam amicissimi Georgii de Martens, auctoris Floræ Würtembergicæ, algarum maris Mediterranei scrutatoris indefessi. —Hering.

197. *Nemalion Natalense,* Hg. Fronde filiformi, ramosa, ramis elongatis, villosis, villis articulatis.

Color olivaceus, chartæ arctè adhærens. *Hab.* ad Port Natal Point, Afr. meridionalis.

Fucus minimus, Hg. Fronde plana ecostata, lineari, dichotoma, integerrima.

Vix pollicaris, fronde semilineam lata, spiraliter torta.

Port Natal.

XIII.—*Observations on the Structure of the Pollen Granule, considered principally in reference to its eligibility as a means of Classification.* By Arthur Hill Hassall, M.R.C.S.L., Corresponding Member of the Dublin Natural History Society.

It has often been a matter of surprise to me, that no one of the numerous and gifted votaries of those bright and beautiful creations, flowers, which are scattered with so profuse a hand over moor and mountain, on hill and through dale, should have fully investigated the structure of the pollen granule in the various tribes of plants, with a view to ascertain whether it could be rendered available for the purpose of classification.

Much has indeed been written upon its general anatomy; but the characters of the granules, as they occur in each genus of plants, appear to have been scarcely at all considered in this country, and almost the only figures which we possess of individual pollen grains are contained in Lindley's 'Introduction to Botany,' and were derived from a work of Purkinje on the subject*.

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* These figures are but little more than mere outlines, and even in this single particular are generally very far from being correct.

On the Continent entire works have been published upon the pollen, accompanied by numerous figures: I allude particularly to Purkinje's work, 'De Cellulis Antherarum fibrosis,' &c.; to that by Fritzsche; and to a memoir by Mohl in the 'Annales des Sciences Naturelles,' all of which have appeared within, I believe, the last ten years.

With the opinions contained in these works I am only acquainted in so far as they are given us by Lindley, as I wished, before consulting them, to form a separate and independent opinion, so that all I shall advance in this paper is to be regarded only as the result of my own investigations, and rests upon my own responsibility. It is my intention to publish, from time to time, a series of papers upon the subject of the Pollen, in some of which I shall give the opinions of the authors to whom I have referred more at length; thus my not doing so at present will be of but little consequence.

Although I do not anticipate that the results of this inquiry will be very considerable in a practical point of view, I yet feel that I ought not to be deterred from the pursuit because I am not at once able to perceive any great utility attached to it; the subject is one of much interest in itself, and may ultimately lead to more than is at present looked for.

I could have wished that an investigation of such nicety and extent had fallen to the lot of some individual of greater capability and experience in microscopical research; but as this is merely an essay, and as I shall advance nothing but what I have fully made out, I trust that the inquiry will not suffer by reason of my comparative inefficiency for the task I have undertaken.

Conceiving then that the want of an accurate knowledge of the form and structure of the pollen grain in the different genera of plants constituted a desideratum in botanical science, I commenced the investigations the results of which I am about to detail early in the spring of last year, continued them throughout the greater part of the summer, and the small amount of time which I have this season been able to spare from professional pursuits has been employed in correcting and confirming the conclusions previously arrived at.

I shall divide my subject into three heads. Under the first head, the pollen generally will be spoken of; under the second, the individual peculiarities of the pollen granule will be noticed; and lastly, the pollen will be considered with a view to ascertain whether it can be rendered available as a means of classification.

First then, of the pollen generally:

The structure, form, and size of the pollen granule varies considerably in different tribes of plants.

There are, however, certain types of structure and of form which occur more frequently than others. Of these, the cylindrical and elliptical are by far the most common; and next, in frequency of occurrence, are those granules of either a triangular or circular form, which are met with in nearly an equal proportion. A great variety of other forms are to be noticed, which it is the object of this paper especially to describe.

The term cylindrical is applied to all those grains which are more or less of an elongated form, are somewhat triangular, and taper towards each extremity, which exhibit a furrow along their upper surface, and are furnished with three pollen tubes; while the word elliptical is used to designate those granules which agreeing somewhat with the former in their lengthened shape, having also a line upon their surface, yet possess but one pollen tube.

On the application of any fluid to pollen of an elongated form, of less density than the fovilla contained in the cells, a remarkable alteration of shape takes place with great quickness. Each grain of pollen, prior to the contact of the liquid, lies on the object-glass of the microscope with its *long* diameter placed horizontally; immediately on its touching it the position of the long diameter is changed, it becomes vertical, and the pollen grain, losing in length, dilates and becomes of a triangular or circular form; and this change of form, which is here produced by the direct application of the water, occurs also naturally previous to the emission of the pollen tubes, arising partly from the absorption of fluid from the tissue of the anther, but mainly from the imbibition of the stigmatic secretion. But if a fluid of greater density than that within the cell be applied, no such change is seen to occur, a contraction of the pollen grain and an exudation of a portion of its contents taking place.

This alteration of form, in both instances, is very satisfactorily explained by a reference to the principle of endosmosis and exosmosis, which is most beautifully exemplified in the interesting though minute subjects of the present inquiry, and all the varied phænomena of which are referred by Dutrochet to capillary attraction.

Each pollen grain consists of a turbid fluid called fovilla, containing numerous active molecular particles; and this fluid is enclosed, according to most observers, in at least two membranes, the outer being called extine, the inner intine, and this is of a highly extensible nature. The only exception to this, according to Mohl, is the pollen of Asclepiadaceous plants, which has but one envelope; but Fritzsche has asserted, according to Lindley, that these plants have both an extine and intine. Fritzsche also states, that in *Caulinia fragilis, Zannichellia pedunculata, Zostera marina,* and *Naias minor,* the pollen has really nothing but the intine present.

That there really are two coatings to the great majority of pollen granules does not admit of a doubt; while a third membrane, intermediate between the extine and intine, has been noticed, first by Mohl and subsequently by Fritzsche, who calls it exintine. Mohl observed it in the pollen of *Taxus, Juniperus, Cupressus* and *Thuja*; and Fritzsche finds it not only in these plants, but also in *Pinus, Cucurbita Pepo,* and *Tigridia Pavonia*; while Mr. Giraud* states (in the third volume of the 'Annals and Magazine of Natural History,' p. 127) that he has noticed it in the pollen of *Crocus vernus.* To these I may add the pollen of the different species of *Banksia* and *Dryandra* as possessing a third membrane, as well as the following list of plants, *Fuchsia fulgens, F. cylindrica, F. thymifolia, F. gracilis,* and *F. coccinea, Stachytarpheta mutabilis, Tilia americana, Calothamnus villosus, Zizyphus Paliurus,* and probably also *Grevillea linearis, Hakia pedunculata, Erythrina laurifolia, Didiscus cæruleus, Fumaria officinalis,* and all other species of *Fuchsia.* It is necessary to observe great caution in deciding upon the presence of a third membrane, as an appearance is frequently observed which might mislead; it arises from the entrance of water within the sac of the intine, separating the fovilla from it, forcing it inwards, and giving it a very defined margin.

At the commencement of this inquiry, I was induced to consider that the reticulation observable on the pollen of *Pancratium, Armeria, Statice, Passiflora,* &c. constituted the basis of a distinct membrane, and in the figures of these which will follow it is so represented. To this opinion I was led by noticing the raised appearance which it presents, especially round the circumference of the granules, as well as from the circumstance of the ends of each grain of pollen in *Pancratium* being destitute of the reticulation; but it is more correct, perhaps, to regard this reticulated appearance as produced by the apposition of the cells of which the extine is formed in these instances.

Fritzsche also speaks of a fourth coat, which is next the extine, and which he calls intextine, as belonging to the pollen of *Clarkia elegans* and other *Onagrariæ.* Of the existence of this membrane in *Clarkia* I have but little doubt, and I believe that it is also present in those species of *Fuchsia* which I have mentioned as possessing a third tunic, as there are in the pollen of these precisely the same appearances upon which the opinion of its presence is founded in *Clarkia elegans.*

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* Mr. Giraud, in the same communication, mentions having seen small opake particles on the surface of the pollen grain of *Polemonium cæruleum,* which exhibit a peculiar motion when the granules are placed in water.

The pollen granules of *Saponaria viscida* present, when viewed through the medium of oil, a very remarkable appearance, which I am only able to explain by supposing that it depends upon some peculiar inversion or pitting of the extine. It conveys the idea of a membrane of a circular form, smaller than the extine, being placed within it, and pollen tubes to the number of ten escaping through apertures in it and extending to the margin of the outer membrane. I refer to this appearance here in the hope of directing the attention of other observers to it, who may perhaps be able to afford a more particular explanation of its nature.

In the long axis of those granules to which the terms cylindrical and elliptical are here applied, as well as of many others, a line or furrow, as has been already remarked, is noticed, concerning the nature of which various conjectures have been hazarded, and none of which afford the true explanation of the phænomenon. Malpighi compared granules of pollen of this kind to grains of wheat, on one side of which a furrow exists; but this does not account for the furrow being visible in every grain at the same time; Guillemin, attempting to account for the constant presence of the line, says that it exists on both sides of the grain. He further supposes this furrow to be a slit intended to facilitate the admission of water into the interior of the granules, and the emission of their contents; neither is this explanation more satisfactory. Fritzsche states it to be a thin part of the extine where the sides of the pollen grain are contracted and meet, producing the appearance of a furrow; while Mr. Giraud regards this line as a mere furrow in the extine which disappears on the application of moisture, in which opinion Professor Graham coincides*; but neither of these gentlemen offer any explanation either as to its origin or use.

The true explanation of the nature of this furrow, about which there are so many opinions, is, that it is a deficiency in the external membrane of the pollen grain, intended to facilitate the egress of the pollen tubes, one of which may be distinctly seen to issue from each; and the fact of its being seen at the same moment in every grain of pollen is accounted for by reference to the form of these granules. Those grains of pollen to which the term cylindrical is applied, are, as has been already noticed, more or less of a triangular or trilobate form, and at each angle, or between each lobe, a furrow exists; so that, as each granule, from its shape, must rest upon one or other of its sides, one angle and one line will necessarily be presented to the eye of the observer. But another explanation is requisite to account for its constant presence in those granules to which the term elliptical is assigned; these, though of an elongated form, like the others, are rounded in their short axes, except on one side, which is slightly flattened and indented. In this indenture the single furrow possessed by these granules is placed; hence it results that each must rest either on its flattened surface, with the furrow looking downwards, as most frequently happens, in which case it will still be apparent through the body of the granule, owing to its transparency; or it will fall on the rounded surface opposite the furrow, which now looks directly upwards. Thus, in whichever way the grain rests, the furrow will still be apparent. Should it alight upon its side it will not remain in this position, but will roll over to the convex surface, which constitutes its centre of gravity*.

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* See Ann. and Mag. of Nat. Hist. already referred to, and Prof. Graham's Third Annual Report, read before the Botanical Society of Edinburgh, March 1841.

The pollen grain of *Crinum amabile* is flattened and broad on *two* surfaces, differing in this particular from the pollen of all other *Amaryllidaceæ* which I have examined, down *each* of which a furrow is placed; and from this form also it follows that one line will ever be opposed to view, as the granules rest upon one of their broad surfaces. And again in *Citrus aurantium*, *Ranunculus acris* and *Rubus fruticosus*, the granules are somewhat elongated, and consist of *four lobes*, between which the fissures are placed; and as they most generally lie on two of the lobes, the other two, with a fissure between them, will, as a matter of course, be turned upwards.

Lastly, many kinds of pollen, as of the *Polygalæ*, *Crucianellæ*, *Labiatæ*, &c., are furnished with a number of furrows, some of which, in all postures, will be visible. A careful examination of the pollen granules of *Convolvulus arvensis*, *Lilium longiflorum*, *Crinum amabile*, and *Ranunculus acris*, will convince any one of the correctness of this explanation; both of the nature of these lines, and of the reasons for their invariable appearance in each granule at the same moment.

In most elliptical pollen, covering each of the fissures, an oval piece of membrane is to be observed, the use of which I conceive to be to prevent the pollen tubes from escaping too readily from the extine, to which it does not appear to be organically united, as on the application of water it is seen to curl up and fall off the granules. It is also met with in *Centaurium*, *Scolymus*, *Dipsacus*, *Scabiosa*, and some allied genera; in these instances it sometimes has an attachment to the extine.

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* Malpighi's comparison of granules of this form to grains of wheat is by no means inapt, but still without the above explanation it is incomplete, inasmuch as it does not account for the constant appearance of the furrow.

The extine, or protective membrane of the pollen grain, on which its shape depends, is of much greater substance than the intine, which is so fine, that rarely can any appreciable thickness of it be detected. It is seldom, if ever, a simple homogeneous membrane, being most generally formed by the apposition of a number of cellules held together by "organic mucus," which give to it a reticulated appearance, very obvious in many of the *Liliaceæ*, as well as in a great variety of other plants. In most hispid pollen, where the same reticulated structure may be traced, from the centre of each cell of the network, either one of the numerous spines which cover this form of pollen grain may be seen to arise, or, where this is absent, an aperture for the passage of a pollen tube will be apparent.

If this view of the structure of the extine be correct, then must it consist of two layers, as each cell forms a shut-sac.

By some observers the external tunic of the pollen grain is said to present a granular *structure*. It often presents a granular *appearance*, which is deceptive, and which I have found to arise from the circumstance of the particles in the fovilla being visible through their transparent coverings.

It has been matter of doubt whether the extine be extensible or not; that it really is so in some cases to a considerable extent, is apparent from the following fact, the only one with which I am acquainted which distinctly proves it. The surface of the pollen granule of *Canna indica* is covered with numerous points, having their free extremities perforated. When the pollen is immersed in water the spines disappear, leaving small apertures on the surface of the now smooth extine; each granule at the same time having enlarged to about thrice its original size. This change occurs with greater rapidity if a dilute mineral acid be used instead of water. All kinds of pollen appear somewhat larger in water, but this depends upon the magnifying power of that liquid. The intine does not expand in an equal proportion with the extine; but being pressed upon equally on all sides by the water which is imbibed by the extine, is forced inwards, and a large space filled with fluid is left between the two membranes.

After diligent and repeated search, I have at last succeeded in making out the plano-convex bodies (*Zwischenorpern*) described by Fritzsche as being particularly visible in some *Mal-*

vaceæ, in a species of *Hibiscus, H. africanus.* He represents them as existing in most hispid pollen, the apertures in which for the passage of the pollen tubes they close, being placed between the extine and intine, with their convex surfaces resting upon the latter. If the pollen of the above-named species of *Hibiscus* be allowed to remain in water for a short time, the pollen tubes will be seen to have emerged some distance from the intine; and upon the extremities of many of them those pieces of membrane will be noticed, which are however more frequently concavo-convex than plano-convex. Although I have not seen these bodies closing the apertures in the extine, it may be inferred with tolerable certainty that they perform the office ascribed to them, from their position at the terminations of the pollen tubes. Those who may wish to observe them will not experience the same difficulty that I have done, knowing the species and the manner in which to look for them. They are not present in the pollen of the *Ipomæœ.*

The surface of all pollen is covered with a thick tenacious matter, which, according to Mohl, is most abundant upon that which is hispid; but it is at least as much so on the pollen of many species of *Liliaceæ,* which are not hispid, but reticulated. If this viscid substance is to be regarded as a secretion, then must the extine be provided with glands, or some other peculiar organization for its formation; for a true secretion can only result from organization of some kind or other, and, in the vegetable kingdom, may be defined to be a new product, eliminated from the sap through the instrumentality of glands or other structural media. My own opinion is, that it is a secretion, if not formed by the external membrane of the pollen grain itself, derived from the cell in which it is originally developed. I was at first inclined to consider it as a mere exudation, consisting of the thinner parts of the fovilla; but its appearance and consistence differ so much from this, that I believe the opinion to be scarcely tenable. This secretion fulfills an important indication in preventing the too easy dispersion of the pollen granules, which it slightly holds together, and which would be scattered far and near, wide of its destined mark, by every breath of wind.

Pollen granules, though usually separate, are occasionally found united. This union is either temporary, the medium which retains them in contact with each other being either a tenacious secretion, or filaments of the cellular tissue derived from the breaking up of the cells in which the granules are originally developed; or it is permanent and organic. We find the first mode of union in the pollen grains of the *Epilobia**, *Salpiglossis atropurpurea*, and in *Lechenaultia formosa*, while the second is met with in all the genera of the natural order *Ericaceæ* which I have had an opportunity of examining, in the *Acaciæ, Mimosæ, Junci*, many species of *Orchidaceæ*, and in *Oxyanthus speciosa*. Some of these grains, though they usually are permanently attached, are yet capable of separation; but others of them again, as the *Ericaceæ*, &c., are so intimately joined, that they never become separated. The number of pollen grains thus united together is definite, being either four, or multiples of four up to sixteen, but the first number is of the most frequent occurrence; thus there are four in the *Ericaceæ, Epilobia, Junci, Orchidaceæ, Oxyanthus speciosa*, and *Salpiglossis atropurpurea, Lechenaultia formosa* and *Mimosa mexicana*. In *Acacia rigens* there are eight, disposed on the same plane; in *Acacia decipiens* twelve, six being disposed on the same plane, while three are placed in the centre, on either side of the flat figure so formed; and in *Acacia linearis* there are sixteen, eight upon the same plane and four on either side. It is to be observed, that dark lines run between every four grains, indicating either their original separation or their tendency to become so separated. When the union of pollen grains occurs in fours, they are either disposed upon the same plane, as in the *Epilobia* and *Lechenaultia formosa*, or they appear as if one was placed upon the other three, all the granules bearing precisely the same relations to each other, and whichever one is uppermost, the rest being similarly circumstanced in reference to it. One exception occurs to the law of the union of pollen grains in fours in *Epilobium roseum*, where they generally unite in threes.

As a rule, but one mode of arrangement prevails among the pollen grains of the same species.

Pollen grains are often held together by a thready substance, supposed to be derived from the rupture and breaking up of the cells in which they are primarily formed, in the meshes of which they become either entangled, or to which they are attached by the secretion which covers their surface. It appears to me that neither the origin nor use of these threads are rightly made out. They are found in great abundance in the pollen of the *Ericaceæ*; *Fuchsiæ, Œnotheræ*, and other *Onagrariæ*.

The size of the pollen granule differs as materially as does its form and structure, as will be obvious from a perusal of the following table of relative sizes, although in the same species and in genera of the same family it is pretty uniform.

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* The granules in *Epilobium angustifolium* are not united, resembling much more those of the Clarkias than the Epilobiums.

The micrometer employed was a glass one, and divided in the ratio of 249,000 spaces to the inch.

Cobæa stipularis		$\frac{5}{249,000}$
Lavatera acerifolia		$\frac{4}{249,000}$
Geranium sylvaticum		$\frac{2\frac{1}{4}}{249,000}$
Fuchsia fulgens		$\frac{2}{249,000}$
Lilium tigrinum	Length	$\frac{1\frac{3}{4}}{249,000}$
	Breadth	$\frac{\frac{3}{5}}{249,000}$
Viola tricolor	Length	$\frac{1\frac{1}{2}}{249,000}$
	Breadth	$\frac{\frac{3}{4}}{249,000}$
Salvia patens		$\frac{1}{249,000}$
Anagallis arvensis	Length	$\frac{\frac{1}{2}}{249,000}$
	Breadth	$\frac{\frac{1}{3}}{249,000}$
Bauera rubioïdes		$\frac{\frac{1}{18}}{249,000}$
Myosotis palustris		$\frac{\frac{1}{50}}{249,000}$
Mimosa marginata		$\frac{\frac{1}{64}}{249,000}$

The colour of the pollen is extremely various and often brilliant. In *Gilia achilleæfolia* and *Petunia violacea* it is of a dark blue. In *Collomia rosea* it is of a bright cærulean blue; deep red in *Cleome spinosa*; of a reddish brown or mahogany colour in *Lilium tigrinum*; and scarlet in *Huchera americana* and *Verbascum Thapsus.* In *Papaver Rhæas* and *Tulipa Gesneriana* nearly black. In *Convolvulus sepium* opake white; and yellow, the most common colour of the pollen, in *Lilium album* and *longiflorum,* owing to the dense yellow-coloured secretion with which the granules are covered. Dr. Lindley says that the pollen occasionally assumes every colour except green; it is however perfectly green in *Pentstemon* *pentaphyllum, Bessera elegans* and *Lythrum Salicaria*; in this last it is curious to notice, that while the pollen of the upper stamina is green, that of the lower ones is of a bright yellow.

Pollen tubes are prolongations of the intine, and are filled with the fovilla, which passes into them by gravitation. They vary much in number, size, and arrangement; they issue either through fissures or apertures in the extine, and where there are three envelopes, through similar provisions in the second also. Except in some few instances, I have not been able to discover any provision in the extine for the escape of the pollen tubes. These exceptions occur in the genera *Canna, Strelitzia, Roscoea* and *Hedychium*, all of which belong to closely-allied orders, and in which the extine, which is of great thickness, forms a shut-sac. If water, and more quickly if dilute nitric acid, be applied to the pollen, the granules are seen to enlarge a little, and the extine to crack irregularly, but often separating into three unequal pieces; while the intine, having undergone no change except a slight increase of size, and still containing the fovilla, frequently disengages itself from its envelope and floats away from it. This cracking of the extine is assuredly the natural means by which the pollen tubes are afforded an outlet; and it is not necessary that the intine should be denuded at any particular spot, for wherever it is so it possesses the power of elongation, or rather *growth*. In one or two cases the apertures are provided with valves, as in the different species of *Passiflora*, as first noticed by Purkinje. Fritzsche has described one valve in the grasses, two in the nettle, four in the orange, and six in the primrose. Although I have searched with care for these valves, I have not been able to detect any trace of them, and am strongly inclined to deny their existence in any of these plants.

The primary form of the pollen of the orange precludes the possibility of its being furnished with regular valves, the pollen tubes issuing through *fissures* and not circular apertures; while had a valve been present in the grasses, I think I must have detected it in the pollen of the *Zea Mays*, which is of a very large size, and in which the apertures for the escape of the pollen tubes are very visible. The nettle I believe to possess *three* pollen tubes.

The emission of the pollen tubes is produced, artificially, by the action of the mineral acids and water, and naturally, partly by the rarefaction of the contents of each pollen granule by the sun's heat * (the rarefied fovilla distends the shell of the pollen grain, which produces pressure upon its contents, and assists in forcing them out in the only direction in which they can issue, namely, through the openings provided for the purpose), partly by the granules imbibing a portion of the stigmatic secretion, some of which gets between the outer and inner membranes, producing pressure upon the latter, and partly by the stimulating effect of that secretion.

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* The effect of heat upon the pollen has occasionally been demonstrated when I have been examining it under a strong reflected light of the sun, by the emission of the pollen tubes, and even rupture of the intine.

Pollen tubes are supposed to be elongated by means of the distension or stretching of the intine. This opinion appears to me to be erroneously entertained. It is difficult to conceive any membrane to be endowed with such immense powers of expansion as would be required for it to afford a covering to the whole pollen tube, lengthened as it often is to such a great extent in its passage through the style. Thus in *Crinum amabile* the pollen tube has to pass through a space 1875 times the diameter of the pollen grain before reaching the ovarium. In *Cleome spinosa* 2719 times. In *Oxyanthus speciosa* 4489 times the diameter of the pollen grain, and in *Colchicum autumnale* 9000 times. Pollen tubes are frequently met with of considerable length on parts of the flower distant from the stigma, proving that the stigmatic fluid is not essential for their growth, although it doubtless favours it.

I am of opinion, therefore, that pollen tubes are growths and not mere elongations of the intine; and that as they grow a vacuum is formed within them, into which the fovilla passes. At the same time, I do not mean to deny the fact of the intine being extensible; it is no doubt highly so, as proved by the great length of the pollen tubes emitted under the action of dilute nitric acid in some cases.

Were pollen tubes but mere extensions of the intine, it might with reason be expected that the size of the granules and consequent extent of the intine would bear some relation to the distance which they have to travel through the stigmatic tissue before reaching the ovary, and that the greater the distance the larger would be the pollen grains; but no such relation exists.

I am at present inclined to regard the active molecular bodies in the fovilla, which have attracted so much the interest and attention of physiologists, as nothing more than particles of that fluid which have become separated into little masses or globules. The fluid nature of these particles is proved by their great diversity of form and size, by their transparency, and by their trailing, or "tailing *," as they pass along the surface of glass. Again, the internal membrane of the pollen grain of *Strelitzia humilis*, when denuded of the extine, presents a cellular appearance, which is owing to the presence of numerous globules of various sizes contained in the fovilla, of which, in this instance, it appears to be entirely composed, and which are seen through its transparent envelope. I could not detect any other bodies but these globules, which I regard as fluid for the reasons just given. The application of iodine to the fovilla, contrary to expectation, produced no effect, and a solution of potash but little apparent results.

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* "Tailing" is a term used by druggists to signify the elongation of form which the globules of impure quicksilver undergo in passing over paper.

I look forward to another opportunity of making more extended observations upon the nature of these so-called molecules.

Being anxious to ascertain whether stimuli would produce any effect upon the pollen, various solutions were applied with a view to determine this point. The results following the various applications employed were as follows:—solutions of the mineral acids, whether sulphuric, nitric or hydrochloric, all occasioned, with more or less degree of force, the protrusion of the pollen tubes. Their mode of action is not very clear; but it may be that they produce *some* astringent effect upon the outer coating of the pollen grain, so as to cause the principle of endosmosis to operate with greater power. Sometimes these acids, and more particularly the dilute sulphuric acid, rupture the inner membrane, and then the fovilla escapes from its interior; but most frequently the pollen tubes are emitted, covered by the intine, which remains entire, and it is to explain this protrusion of them that the above explanation is offered. The concentrated sulphuric acid almost always destroys the intine, and frequently also blackens and chars the extine. A solution of the nitric acid, in the proportion of two of the strong acid to three of water, is perhaps the best application for occasioning the emission of the pollen tubes; but it is as well to have solutions of all the acids of various strengths, for where one fails another will often produce the desired effect. The action of the hydrochloric acid is weaker than that of either of the others. Solutions of *æther* and *sal volatile* produced a marked effect. When either of these were allowed to fall from a glass on the pollen, its granules became distinctly agitated and moved about with considerable velocity, sometimes for the space of two or three minutes. A like effect, but to a much less extent, resulted from the employment of tincture of cantharides, tincture of capsicum, proof spirit, solution of nitrate of silver in proof spirit, and essence of ginger, while liquor ammoniæ and potassæ produced no result. It is to be remarked, that all those applications which occasioned any motion of the pollen contained a greater or less proportion of spirit in them, and that the most volatile liquids, æther and sal volatile, gave rise to the most marked effect. This very obvious motion of the pollen granules is certainly not to be referred to any action of the irritants employed upon them, but to currents in the fluids. That this is the real explanation to be given of the phænomenon is satisfactorily proved by the two following facts: 1st. If a small quantity of either æther or sal volatile be allowed to remain for a few minutes in a watch-glass and the pollen be then added, no motion will follow, the more volatile portion of these liquids having evaporated; and 2nd, the particles of flour will be equally affected by the application of the before-mentioned solutions. Water also will sometimes cause the emission of the pollen tubes, the principle of endosmosis being called into operation. This emission of the pollen tubes is not the act of an instant, but occupies an appreciable time, producing the impression on the mind of some continuous force operating in occasioning it, such as that of endosmosis already referred to.

The extreme care taken by nature to ensure the fertilization of the seed, a process so essential to the well-being and almost the existence of man, is very striking, and some of the beautiful provisions by which this important effect is so constantly brought about, it is my intention now to notice. First, then, the lining membrane of the anther, as pointed out by Mirbel in 1808, is composed of cellular tissue of a fibrous character, which forms an innumerable quantity of little springs* which are highly elastic, and when dry contract and pull open the valves of the anther, allowing the pollen to escape. This elastic tissue is deprived of its fluid by means of the endosmosis carried on by each individual grain of pollen, and this exhaustion of its fluid is only completed at the period of the maturity of the pollen. Thus by this unerring contrivance, not alone is the precise period of the opening of the anther, viz. at the perfection of the pollen, provided for and determined on, but it results from it also, that the pollen only should be exposed in the weather most suitable for the performance of its function, that is, in dry weather. The injurious effect of a continuance of rain in destroying the fertilizing power of the pollen is well known, and is to be explained by the rupture of the granules from the great quantity of water imbibed by endosmosis; and this consequence of wet would be attended with more serious results were it not for another wise and effectual provision. The individual flowers composing a bunch, as well as the different bunches of a plant or shrub, come into blossom at successive intervals, the order of their expansion depending mainly, I believe, upon the position of the flower, whether it be in a more direct line or not for the accession of sap, on the size of the peduncle, as well as on the order of the development of the flower buds themselves*: thus, if the pollen at one period be destroyed, it is soon replaced by the unfolding of more blossoms and bursting of anthers: this constitutes the second means by which the efficiency of the pollen is ensured. We find a third in the position of the stamens in reference to the pistil, which they often surround, embrace, or overhang, so as to render the application of the pollen to the stigmatic surface a matter of certainty.

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* This peculiar arrangement of the fibres of the lining membrane of the anther is very plainly seen in the common nettle.

Again the filaments of some anthers are furnished with elastic joints, which at a certain period, that is, when the pollen and stigma are in a fit condition, contract and start towards the pistil with a jerk, dispersing the contents of the anthers around them by the suddenness and violence of the motion. I may perhaps under this head refer to two instances of irritability, which I have never seen mentioned in books, and which are certainly not generally known. The first occurs in *Cornus canadensis*: the corolla of each flower, a number of which are contained in a common involucrum, consists of four segments; these for some time are folded over the other floral organs and meet in a common central point, where they cohere by means of some secretion. Towards their tips, on what is the upper surface, while thus closed, arises a long spine or hair. The stamina are also four in number, and arise from the top of the calyx in the intervals between the petals, and at about half their length are bent inwards towards the pistil at a very acute angle, being retained in this position by the corolla which infolds them. The base of each petal, as well as the angle of inflection of each filament, are furnished with an elastic joint, so that if one of the spines be slightly touched, not only does each segment of the corolla fly back, but the stamina, the restraint being removed from off them, start up, scattering the pollen of the anthers around them, some of which, it is beautiful to observe, in viewing this phænomenon under a low power of the microscope, invariably alights upon the stigma, and is there retained by means of the secretion with which it is furnished.

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* The cause of the irregular ripening of many kinds of fruits and seeds admits of a similar explanation.

If the joint of the filament be touched where it protrudes between the petals, no such effect as I have described will be produced, but the moment the hair is touched it takes place; now the presence of these hairs affords a very interesting instance of design. They are connected with the joint of each petal by means of a raised line of elastic tissue which runs along their centre, and which doubtless serves to convey the impression or shock, imparted to the hairs most frequently by means of insects, to the joint, causing it to contract; the dispersion of the pollen and consequent fecundation of the ovule being thereby rendered more certain.

The second instance to which I shall refer is witnessed in the common stinging nettle, *Urtica dioica*: the number of stamina in this plant is likewise four; these are inclosed in a chalice or cup composed of four sepals, and the filaments are coiled inwards; on the reflection of these sepals, or on the occurrence of any shock, the filaments disengage themselves, and not merely straighten, but turn as much outwards as they were previously coiled inwards, the pollen being scattered, as in the former case, around them. If the filament of each stamen be examined with the microscope, one surface of it, that is, the one which formed the concavity before its disengagement, but after, the convexity, is observed to be ringed, in the same way as the elastic spring of the sporangia of Ferns. An analogous instance of irritability occurs in *Parietaria*, an allied genus*.

The stigmata of some plants, as for example of *Pavetta Caffra*, the *Campanulæ* &c., extend so much beyond and above the anthers, that it is difficult to conceive in what way the pollen can reach them; but observation affords an explanation of the means: at the time of the bursting of the anthers the stigma is on a *level* with *them*, and, apparently stimulated by contact with the pollen grains, subsequently rises up, carrying with it in its progress a quantity of the pollen.

Moreover, the application of the pollen to the stigma is rendered more certain by a cause, which, when not rightly considered, may appear trifling, but which, in its results, is far from being so. I allude to the agency of insects, and of these, especially to the *Aphides*, and our benefactor the Bee, that busy labourer for man, who in rifling a flower of part of its sweets, yet in doing so confers upon it the means of its perpetuity by dispersing the pollen around, some of which never fails to reach the stigma. To many insects the pollen doubtless forms an important article of food, as does also the honeyed secretion found in so many flowers, and are both the inducements which bring them so many visitants. The chief use of honey in the œconomy of a plant I conceive to be to allure insects for the purpose referred to.

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* I now know that *this second* example of vegetable irritability *or elasticity of tissue* is alluded to in Lindley's 'Natural Arrangement,' and also in Henslow's 'Descriptive and Physiological Botany.'

The last provision to which I shall advert, consists in the amazing number of pollen granules produced by most flowers. In a single blossom of *Leontodon Taraxacum* I counted no less than 243,600 pollen granules. A flower of Pæony furnishes on an average 174 stamina, each containing 21,000 granules; these multiplied together give a total of 3,654,000; and in an entire Rhododendron plant the pollen grains amounted to the wonderful number of 72,620,000. This last result was arrived at by computing the number of anthers in each flower, with the contents of one, and the number of flowers and bunches. Great as these amounts are, they sink into comparative insignificance when contrasted with the myriads produced by a single forest tree. A bulrush gave 144 grs. by weight of pollen. Immense as the quantity of pollen is, provided for the fertilization of each flower, it is yet all necessary, so much being destroyed by various instrumentalities, to ensure the certainty of a process, the failure of which would be attended with such calamitous results. Nature is seldom uselessly prodigal of her resources.

It is interesting to observe the relation which frequently exists between the quantity of pollen and the more or less direct means of its application to the stigma; this relation, however, is modified by the number of ova to be fertilized. Upon this subject I hope shortly to make some detailed observations.

Various particulars referred to in the foregoing pages will be exhibited in the figures which are to accompany the second portion of this communication.

[To be continued.]

XIV.—*Indian* Cyprinidæ. By JOHN M'CLELLAND, Assistant Surgeon Bengal Medical Service.

[Continued from p. 46.]

24. THE Opsarions are *Cyprinidæ* that live upon other species of their own class; they are no less remarkable for the peculiarity of their colours than for their remarkable structure and habits. Instead of the longitudinal stripes of the Perilamps, they are characterized by transverse bands or spots, having a tendency to form cross bars on the sides. The analogy between the structure and character of the Opsarions